Efficient calculation of electron cutout factor using Eclipse electron Monte Carlo model

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INTRODUCTION

Treatment with MeV electrons is a popular technique for superficial lesions in radiation therapy. Usage of small sized electron cutouts compromises the lateral charge particle equilibrium and mandates cutout factor (CF) measurement for accurate dosimetry. Traditionally, cutout factor is measured as the ratio of charge collected at d_{max} with and without the cutout in water or water equivalent phantoms. It requires phantom setup with ion chamber, rotation of the collimator to align the largest opening of the cutout, dose delivery and calculations. In this study, we introduce an efficient alternative technique for cutout factor measurements, where we calculate the CF using electron Monte Carlo directly from the treatment planning system.

METHOD

Electron Monte Carlo (eMC) algorithm in Eclipse 15.5 was used to calculate the ratio of dose with and without cutout in a water phantom. In Eclipse, water phantom can be generated in different sizes in cuboid and cylindrical shapes. We generated a cubic water phantom with 30 cm sides. For the MC study, circular blocks were added as predefined shapes in Eclipse. For irregular cutouts, we used a transparent sheet and freehand tool to reproduce the cutouts shape in Eclipse. A 2 cm straight line was drawn on the transparent sheet to find the correct scaling and zoom factor in Eclipse. In Eclipse dose calculation options, we set the desired average uncertainty in d_{max} region to 2% and dose calculation grid to 1 mm. A reference point was dropped at the depth of the dmax to track the dose. The ratio of the dose calculated with and without the cutout was considered as the CF for each cutout.

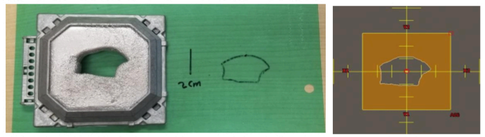

Figure 1. Irregular cutout drawing on transparent sheet (left) and the corresponding block in Eclipse (right)

VALIDATION OF THE CALCULATION

To validate our results, five different cerrobend cutouts including two irregular and three circular cutouts with 2.2 cm, 3.2 cm and 4 cm diameter were made and used for CF calculation at 100 cm and 110 cm SSDs. A 6 cm x 6 cm electron cone was used in this study. Measurements were done using a Varian Truebeam Linac for two different electron energies of 6 MeV and 15 MeV. A PinPoint ion chamber (0.016 cc, PTW) was placed in a slab of solid water phantom and extra layers of solid water were added to make a proper build up and locate the chamber at d_{max} for each energy. A total of 500 MUs was delivered for each measurement.

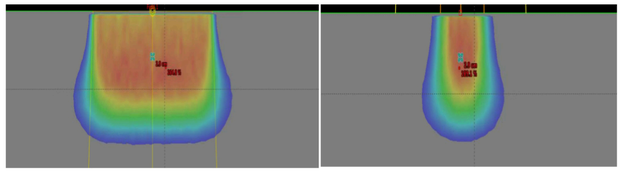

Figure 2. Dose distribution of 15 MeV electron for open cone (left) and with the cutout (right)

For irregular cutouts, the collimator was rotated to align the maximum opening of the cutout with the chamber axis to minimize partial volume effect. The ratio of chamber readings with and without the cutout was considered at CF. For every cutout, CFs for two different energies and at two different SSDs were measured and compared with eMC calculated results and the relative error was reported for each measurement.

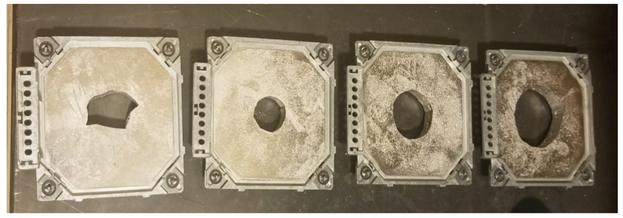

Figure 3. Circular and one of the irregular cutouts used for CF measurement

RESULTS

- ✓ A good agreement was observed between measured and calculated values.
- ✓ For 6 MeV electrons, the difference (mean ± std) between measured and calculated CF values were 3.1% ± 2.1% and 3.0% ± 2.0% at 100 cm and 110 cm SSD respectively.
- ✓ The corresponding values for 15 MeV electrons were 1.6% ± 1.0% and 1.8% ± 1.2%.

Table 1. A comparison between measured and calculated CFs for different cutouts, energies and SSDs.

Cutout shape	Energy	SSD (cm)	CF measured	CF Calculated	Error (%)
Circular 2.2 cm	6 MeV	100	0.76	0.80	5
		110	0.49	0.50	2
	15 MeV	100	0.84	0.83	1
		110	0.77	0.74	4
Circular 3.2 cm	6 MeV	100	0.92	0.88	4
		110	0.75	0.73	3
	15 MeV	100	0.94	0.92	2
		110	0.91	0.89	2
Circular 4 cm	6 MeV	100	0.98	0.98	0
		110	0.91	0.91	0
	15 MeV	100	0.99	0.96	3
		110	0.97	0.96	2
Irregular #1	6 MeV	100	0.81	0.87	6
		110	0.57	0.61	6
	15 MeV	100	0.87	0.89	2
		110	0.81	0.82	1
Irregular #2	6 MeV	100	0.94	0.95	1
		110	0.79	0.83	4
	15 MeV	100	0.96	0.96	0
		110	0.93	0.92	1

The difference between estimated and measured CFs were slightly higher for lower energy (6 MeV) electrons as compared with 15 MeV electrons.

CONCLUSIONS

- ➢ As an alternative to the CF measurement, we have introduced an efficient calculation method using eMC model in Eclipse.
- ➢ We showed that the difference between measured and calculated CFs is small, and eMC can be used to calculate the CFs.
- ➢ The small differences between measured and calculated CF values could be a result of imperfect cutout shape transfer into TPS and uncertainties associated with measurement process.
- ➢ Further studies are in progress to validate our results with more cutouts, cones and energies.

REFERENCES

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